

REPORT DOCUMENTATION PAGE

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4. TITLE AND SUBTITLE Final Report: Genetic Analysis of Seed Isoflavones, Protein, and Oil Contents in Soybean [Glycine max (L.) Merr.]		5a. CONTRACT NUMBER W911NF-11-1-0178		
		5b. GRANT NUMBER		
		5c. PROGRAM ELEMENT NUMBER 206022		
6. AUTHORS My Abdelmajid Kassem, Stella Kantartzzi		5d. PROJECT NUMBER		
		5e. TASK NUMBER		
		5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAMES AND ADDRESSES Fayetteville State University Sponsored Research & Programs 1200 Murchison Road Fayetteville, NC 28301 -4252		8. PERFORMING ORGANIZATION REPORT NUMBER		
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13. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.				
14. ABSTRACT Soybean (Glycine max L.) is an important crop in the US and worldwide. It has numerous health benefits because of its high contents of protein, oil, isoflavones, and other bioactive compounds. However, it is susceptible to many biotic stresses such as fungal, bacterial, and viral diseases and abiotic stresses such as drought and salinity. The objectives of this funded project were to map quantitative trait loci (QTL) for protein, oil, and isoflavones contents in three recombinant inbred line (RIL) populations of soybean. We have achieved 100% of the goals. We have constructed the recombinant inbred lines based on the three recombinant inbred line (RIL) populations (DT 120100D)				
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b. ABSTRACT UU		c. THIS PAGE UU		19b. TELEPHONE NUMBER 910-672-1692

Report Title

Final Report: Genetic Analysis of Seed Isoflavones, Protein, and Oil Contents in Soybean [Glycine max (L.) Merr.]

ABSTRACT

Soybean (*Glycine max* L.) is an important crop in the US and worldwide. It has numerous health benefits because of its high contents of protein, oil, isoflavones, and other bioactive compounds. However, it is susceptible to many biotic stresses such fungal, bacterial, and viral diseases and abiotic stresses such as drought and salinity. The objectives of this funded project were to map quantitative trait loci (QTL) for protein, oil, and isoflavones contents in three recombinant inbred line (RIL) populations of soybean. We have achieved 100% of the goals. We have constructed the genetic linkage maps based on the three recombinant inbred line (RIL) populations 'PI 438489B' by 'Hamilton' (PIxH, n=54) (Kassem et al., 2012), 'Maryland 96-5722' by 'Spencer' (MxS, n=100) (Akond et al., 2013), and 'Hamilton' by 'Spencer' (HxS, n=100) (Akond et al., 2014, under review). We also mapped quantitative trait loci (QTL) for protein, oil, isoflavone contents as well as other important agronomic traits in each of these RIL populations. The results have been disseminated through (1) high quality manuscripts published in well-respected international journals and (2) poster and oral presentations in local, regional, and international conferences. The results are summarized below.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

08/20/2012 5.00 Salvador Virginia, Megan Pagan, Melissa Cooper, Stella K. Kantartzzi, Khalid Meksem, My Abdelmajid Kassem. Genetic Analysis of Relative Water Content (RWC) in Two Recombinant Inbred Line Populations of Soybean [Glycine max (L.) Merr.], Journal of Plant Genome Sciences, (04 2012): 46. doi: 10.5147/jpgs.2012.0058

TOTAL: **1**

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

(c) Presentations

Kassem MA, Akond M, S Liu, M Boney, SK Kantartzzi, K Meksem, N Bellaloui, and DA Lightfoot, and. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, and Five Major Fatty Acids' Contents in Soybean. NC Academy of Science 111th Annual Meeting, March 28–29, 2014, NC Museum of Natural Sciences, Raleigh, NC. Oral Presentation.

Anderson JA, A Masum, MA Kassem, K Meksem, and S Kantartzzi. Quantitative Trait Loci Underlying Resistance to Sudden Death Syndrome (SDS) in MD96-5722 By 'Spencer' Recombinant Inbred Line Population of Soybean. CSA, CSSA, & SSSA International Annual Meeting, November 2–5, 2014, Long Beach, CA.

Akond M, L Schoener, J Anderson, SK Kantartzzi, K Meksem, Q Song, D Wang, Z Wen, DA Lightfoot, and MA Kassem. A SNP-Based Genetic Linkage Map of Soybean Using the SoySNP6K Illumina Infinium BeadChip Genotyping Array. Plant and Animal Genome Conference XXII, January 11–15, 2014, San Diego, CA, USA.

Akond M, R Bazelle, B Ragin, H Herrera, U Kaodi, C Akbay, SK Kantartzzi, V Njiti, A Barakat, K Meksem, DA Lightfoot, and MA Kassem. Additional Quantitative Trait Loci and Candidate Genes for Seed Isoflavone Content in Soybean. Plant and Animal Genome Conference XXII, January 11–15, 2014, San Diego, CA, USA.

Kassem MA. "Quantitative Trait Loci (QTL) for Moisture, Proteins, and Oil Contents in 'PI 438489B' By 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean [Glycine max (L.) Merr.]". The 110th Meeting of the North Carolina Academy of Science, April 5–6, 2013, UNC Pembroke, Pembroke, NC. Oral Presentation.

Kassem MA. Quantitative Trait Loci (QTL) for Seed Isoflavones Content in 'PI 438489B' By 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean [Glycine max (L.) Merr.]. The First International American Moroccan Agricultural Sciences Conference – AMAS Conference I, March 18–19, 2013, Rabat, Morocco. Oral Presentation.

Bazzelle Richard, Bobby Ragin, Stella Kantartzzi, Khalid Meksem, Masum Akond, and MA Kassem. Quantitative Trait Loci for Seed Isoflavones in the 'PI 438489B' by 'Hamilton' Recombinant Inbred Lines of Soybean [Glycine max (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12–16, 2013, San Diego, CA, USA.

Masum Akond, Ragin Bobby, Willsheana Clark, Stella K. Kantartzzi, Khalid Meksem, and MA Kassem. Row Spaces can affect Agronomic Traits in Soybean [Glycine max (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12–16, 2013, San Diego, CA, USA.

Masum Akond, Bobby Ragin, Richard Bazzelle, Stella K. Kantartzzi, Khalid Meksem, and MA Kassem. Quantitative Trait Loci for Moisture, Protein, and Oil Content in Soybean [Glycine max (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12–16, 2013, San Diego, CA, USA.

Number of Presentations: 9.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

(d) Manuscripts

Received Paper

03/22/2012 1.00 Khaled Ouertani, Evandrew Washington, Patricia Lage, Stella K. Kantartzi, David A. Lightfoot, My Abdelmajid Kassem. Comparison of Early and Conventional Soybean Production Systems for Yield and other Agronomic Traits, *Atlas Journal of Plant Biology* (01 2011)

03/22/2012 4.00 My Abdelmajid Kassem, Laura Ramos, Leonor Leandro, Gladys Mbofung, David L. Hyten, Stella K. Kantartzi, Robert L Grier, Victor N. Njiti, Silvia Cianzio, Khalid Meksem. The 'PI 438489B' by 'Hamilton' SNP-Based Genetic Linkage Map of Soybean [*Glycine max* (L.) Merr.] Identified Quantitative Trait Loci that Underlie Seedling SDS Resistance, *Journal of Plant Genome Sciences* (01 2012)

03/22/2012 3.00 Brensha Williams, Stella K. Kantartzi, Khalid Meksem, Robert L. Grier, Abdelali Bara-kat, David A Lightfoot, My Abdelmajid Kassem. Genetic Analysis of Root and Shoot Traits in the 'Essex' By 'Forrest' Recombinant Inbred Line (RIL) Population of Soybean [*Glycine max* (L.) Merr.], *Journal of Plant Genome Sciences* (01 2012)

03/22/2012 2.00 Ivey Sherrie, Ouertani Khaled, Evandrew Washington, Patricia Lage, Samantha Woods, Stella K. Kantartzi, Khalid Meksem, David A Lightfoot, My Abdelmajid Kassem. Evaluation of Several Agronomic Traits in 'Essex' By 'Forrest' Recombinant Inbred Line Population of Soybean [*Glycine max* (L.) Merr.], *Atlas Journal of Plant Biology* (12 2011)

08/20/2012 6.00 Ragin Bobby1, , Richard Bazelle1, , Wilsheana Clark1, , Stella K. Kantartzi2, , Khalid Meksem2,, Masum Akond1 & , My Abdelmajid Kassem1. Genetic Analysis of Yield Components in the PI 438489B by 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean [*Glycine max* (L.) Merr.], *Journal of Agricultural Science* (05 2012)

08/20/2012 7.00 ASM G. Masum Akond1, Bobby Ragin1, Richard Bazzelle1, Stella K. Kantartzi2, Khalid Meksem2, and My Abdelmajid Kassem1. Quantitative Trait Loci Associated with Moisture, Protein, and Oil Content in Soybean [*Glycine max* (L.) Merr.], *Journal of Agricultural Science* (06 2012)

08/25/2013 8.00 Masum Akond1, Bazelle Richard1, Bobby Ragin1, Harmin Herrera2, Umerah Kaodi2, Cevdet Akbay2, Stella K. Kantartzi3, Victor Njiti4, Abdelali Barakat5, Khalid Meksem3, David A Lightfoot3 and My Abdelmajid Kassem*1. Additional Quantitative Trait Loci and Candidate Genes for Seed Isoflavone Content in Soybean, *Journal of Plant Sciences* (08 2013)

08/25/2013 10.00 Masum Akond1, Melanie Boney1, Lauren Schoener1, Stella K. Kantartzi2, Khalid Meksem2, Nacer Bellaloui3, David A Lightfoot2 and My Abdelmajid Kassem1*. Quantitative Trait Loci for Seed Isoflavone Contents in 'Maryland' by 'Spencer' Recombinant Inbreed Lines of Soybean, *Journal of Agricultural and Food Chemistry* (09 2013)

08/25/2013 9.00 Masum Akond1, Lauren Schoener1, Stella K. Kantartzi2, Khalid Meksem2, Qijian Song3, Dechun Wang4, Zixiang Wen5, David A Lightfoot2 and My Abdelmajid Kassem1*. A SNP-Based Genetic Linkage Map of Soybean Using the SoySNP6K Illumina Infinium BeadChip Genotyping Array, *Journal of Plant Genome Sciences* (08 2013)

09/13/2014 12.00 Masum Akond, Bobby Ragin, Richard Bazzelle, Wilsheana Clark, Stella K. Kantartzi, Khalid Meksem, and My Abdelmajid Kassem. Effect of Two Row Spaces on Several Agronomic Traits in Soy- bean [*Glycine max* (L.) Merr.], *Atlas Journal of Plant Biology* (06 2012)

09/13/2014 13.00 M. Akond, Bazelle Richard1, Bobby Ragin1, Harmin Herrera2, Umerah Kaodi2, Cevdet Akbay2, Stella K. Kantartzis3, Victor Njiti4, Abdelali Barakat5, Khalid Meksem3, David A Lightfoot3, and My Abdelmajid Kassem1 . Additional Quantitative Trait Loci and Candidate Genes for Seed Isoflavone Content in Soybean , Journal of Agricultural Science (09 2013)

09/13/2014 14.00 Masum Akond1, Shiming Liu2, Lauren Schoener1, James A. Anderson2, Stella K. Kantartzis2, Khalid Meksem2, Qijian Song3, Dechun Wang4, Zixiang Wen5, David A. Lightfoot2, and My Abdelmajid Kassem1*. A SNP-Based Genetic Linkage Map of Soybean Using the SoyS- NP6K Illumina Infinium BeadChip Genotyping Array , Journal of Plant Genome Sciences (09 2013)

09/13/2014 15.00 Masum Akond1, Shiming Liu2, Melanie Boney1, Stella K. Kantartzis2, Khalid Meksem2, Nacer Bellaloui3, David A. Lightfoot2, My Abdelmajid Kassem1# . Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, and Five Major Fatty Acids' Contents in Soybean, American Journal of Plant sciences (10 2013)

09/13/2014 16.00 Masum Akond,† Shiming Liu,§ Stella K. Kantartzis,§ Khalid Meksem,§ Nacer Bellaloui,# David A. Lightfoot, § Jiazheng Yuan,? Dechun Wang,? and My Abdelmajid Kassem*,† . Quantitative Trait Loci for Seed Iso? avone Contents in 'MD96-5722' by 'Spencer' Recombinant Inbred Lines of Soybean , Journal of Agricultural and food chemistry (09 2013)

09/13/2014 17.00 Masum Akond1, Stella K. Kantartzis2, Khalid Meksem2, Nacer Bellaloui3, David A Lightfoot2, , My Abdelmajid Kassem1* . Genomic Regions Containing Quantitative Trait Loci (QTL) Underlying Sucrose, Raffinose and Stachyose Contents in the 'MD 96-5722' by 'Spencer' Recombinant Inbred Line (RIL) Population of Soybean , PLoS ONE (01 2014)

09/13/2014 18.00 Laila Khandaker †, Masum Akond†, Shiming Liu§, Stella K. Kantartzis§, Khalid Meksem§, Nacer Bellaloui#, David A Lightfoot§, and My Abdelmajid Kassem. Seed Amino Acids QTL Detected by SNP Markers in the 'MD 96-5722' by 'Spencer' RIL Population of Soybean , Journal of Agricultural and Food Chemistry (02 2014)

TOTAL: 16

Number of Manuscripts:

Books

Received Book

TOTAL:

ReceivedBook Chapter**TOTAL:****Patents Submitted****Patents Awarded****Awards**

April 2014 "Academician of The Year Award"; Department of Biological Sciences; Fayetteville State University

Dec. 2013 "Excellence in Grant Proposal Submission Award"; Fayetteville State University; Board of Trustees Meeting on December 12, 2013.

April 2012 "CAS Academician of The Year" Award; College of Arts and Sciences; Fayetteville State University

Graduate Students

<u>NAME</u>	<u>PERCENT SUPPORTED</u>	Discipline
Bobby Ragin	0.50	
Melanie Boney	0.50	
Zenis Ambrocio	0.00	
FTE Equivalent:	1.00	
Total Number:	3	

Names of Post Doctorates

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
Masum Akond	1.00
FTE Equivalent:	1.00
Total Number:	1

Names of Faculty Supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Names of Under Graduate students supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>	Discipline
Willsheana Clark	0.00	BS Biology
Jonela Rogers	0.00	BS Biology
Lauren Schoener	0.10	BS Biology
Laura House	0.00	BS Biology
Laura Gore	0.00	BS Biology
Hamza Kharabsheh	0.10	MS Biology
Fahim Lodhi	0.00	BS Biology
Charity Baldwin	0.00	BS Biology
FTE Equivalent:	0.20	
Total Number:	8	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period:

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:.....

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:.....

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):.....

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:.....

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:

Names of Personnel receiving masters degrees

<u>NAME</u>
Bobby Ragin (Spring 2014)
Melanie Boney (Fall 2014)
Zenis Ambrocio (Fall 2014)
Total Number:
3

Names of personnel receiving PhDs

NAME

Total Number:

Names of other research staff

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
FTE Equivalent:	
Total Number:	

Sub Contractors (DD882)

Inventions (DD882)

The objectives of this grant were to genetically map quantitative trait loci (QTL) for seed isoflavones, protein, and oil contents in three recombinant inbred line (RIL) populations of soybean focusing on one RIL population per year (Table 1):

Table 1. A summary of the three-year period of the grant, its objectives, achievements, and evidences.

Year	Objectives	Achieved / In Progress	Evidence
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Year 1:

June 1, 2011 – July 31, 2012
(2011-2012)

Map QTL for Seed Protein Contents in PI 438489B by 'Hamilton' RIL population. Achieved
Manuscripts:

Kassem MA, L Ramos, L Leandro, G Mbofung, DL Hyten, SK. Kantartzi, RL Grier, VN Njiti, S Cianzio, and K Meksem. The 'PI 438489B' by 'Hamilton' SNP-Based Genetic Linkage Map of Soybean [Glycine max (L.) Merr.] Identified Quantitative Trait Loci that Underlie Seedling SDS Resistance. *Journal of Plant Genome Sciences* 1(1): 18-30, 2012.

Akond M, B Ragin, R Bazzelle, SK Kantartzi, K Meksem, and MA Kassem. Quantitative Trait Loci Associated with Moisture, Protein, and Oil Contents in Soybean [Glycine max (L.) Merr.]. *Journal of Agricultural Science* 4 (11): 16-25, October 2012.

Abstracts:

Kassem MA. "Quantitative Trait Loci (QTL) for Moisture, Proteins, and Oil Contents in 'PI 438489B' By 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean [Glycine max (L.) Merr.]". The 110th Meeting of the North Carolina Academy of Science, April 5-6, 2013, UNC Pembroke, Pembroke, NC.

Masum Akond, Ragin Bobby, Willsheana Clark, Stella K. Kantartzi, Khalid Meksem, and MA Kassem. Row Spaces can affect Agronomic Traits in Soybean [Glycine max (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12-16, 2013, San Diego, CA, USA.

Masum Akond, Bobby Ragin, Richard Bazzelle, Stella K. Kantartzi, Khalid Meksem, and MA Kassem. Quantitative Trait Loci for Moisture, Protein, and Oil Contents in Soybean [Glycine max (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12-16, 2013, San Diego, CA, USA.

Map QTL for Seed Oil Contents in PI 438489B by 'Hamilton' RIL population.

Achieved Manuscripts:

Kassem MA, L Ramos, L Leandro, G Mbofung, DL Hyten, SK. Kantartzi, RL Grier, VN Njiti, S Cianzio, and K Meksem. The 'PI 438489B' by 'Hamilton' SNP-Based Genetic Linkage Map of Soybean [Glycine max (L.) Merr.] Identified Quantitative Trait Loci that Underlie Seedling SDS Resistance. *Journal of Plant Genome Sciences* 1(1): 18-30, 2012.

Akond M, B Ragin, R Bazzelle, SK Kantartzi, K Meksem, and MA Kassem. Quantitative Trait Loci Associated with Moisture, Protein, and Oil Contents in Soybean [Glycine max (L.) Merr.]. *Journal of Agricultural Science* 4 (11): 16-25, October 2012.

Abstracts:

Kassem MA. "Quantitative Trait Loci (QTL) for Moisture, Proteins, and Oil Contents in 'PI 438489B' By 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean [Glycine max (L.) Merr.]". The 110th Meeting of the North Carolina Academy of Science, April 5-6, 2013, UNC Pembroke, Pembroke, NC.

Masum Akond, Ragin Bobby, Willsheana Clark, Stella K. Kantartzi, Khalid Meksem, and MA Kassem. Row Spaces can affect Agronomic Traits in Soybean [Glycine max (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12-16, 2013, San Diego, CA, USA.

Map QTL for Seed Isoflavone Contents in PI 438489B by 'Hamilton' RIL population. Achieved Manuscripts:

Akond M, B Richard, B Ragin, H Herrera, U Kaodi, C Akbay, SK Kantartzi, VN Njiti, A Barakat, K Meksem, DA Lightfoot, and MA Kassem. Additional Quantitative Trait Loci and Candidate Genes for Seed Isoflavone Content in Soybean. *Journal of Plant Science* 2013, Submitted.

Abstracts:

Kassem MA. Quantitative Trait Loci (QTL) for Seed Isoflavones Content in 'PI 438489B' By 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean [Glycine max (L.) Merr.]. The First International American Moroccan Agricultural Sciences Conference – AMAS Conference I, March 18–19, 2013, Rabat, Morocco. Oral Presentation.

Bazzelle Richard, Bobby Ragin, Stella Kantartzi, Khalid Meksem, Masum Akond, and MA Kassem. Quantitative Trait Loci for Seed Isoflavones in the 'PI 438489B' by 'Hamilton' Recombinant Inbred Lines of Soybean [Glycine max (L.) Merr.]. Plant and

Year 2:
August 1, 2012 – July 31, 2013
(2012-2013)

Map QTL for Seed Protein Contents in 'MD 96-7522' by 'Spencer' RIL population. In Progress Manuscripts:

Akond M, L Schoener, SK Kantartzzi, K Meksem, Q Song, D Wang, Z Wen, DA Lightfoot, and MA Kassem. A SNP-Based Genetic Linkage Map of Soybean Using the SoySNP6K Illumina Infinium BeadChip Genotyping Array. *Journal of Plant Genome Sciences* 2013, Submitted – August 6, 2013.

Akond M, N Bellaloui, M Bonie, SK Kantartzzi, K Meksem, and MA Kassem. Quantitative Trait Loci for Seed Protein and Oil Contents in the 'MD 96-7522' by 'Spencer' Recombinant Inbred Lines of Soybean [*Glycine max* (L.) Merr.]. *Journal of Plant Genome Sciences* 2013, In Preparation.

Abstracts:

Several abstracts will be presented at the International Plant and Animal Genome Conference XXII that will be held January 11–15, 2014 in San Diego, CA.

Map QTL for Seed Oil Contents in 'MD 96-7522' by 'Spencer' RIL population.
In Progress Manuscripts:

Akond M, L Schoener, SK Kantartzzi, K Meksem, Q Song, D Wang, Z Wen, DA Lightfoot, and MA Kassem. A SNP-Based Genetic Linkage Map of Soybean Using the SoySNP6K Illumina Infinium BeadChip Genotyping Array. *Journal of Plant Genome Sciences* 2013, Submitted – August 6, 2013.

Akond M, N Bellaloui, M Bonie, SK Kantartzzi, K Meksem, and MA Kassem. Quantitative Trait Loci for Seed Protein and Oil Contents in the 'MD 96-7522' by 'Spencer' Recombinant Inbred Lines of Soybean [*Glycine max* (L.) Merr.]. *Journal of Plant Genome Sciences* 2013, In Preparation.

Several abstracts will be presented at the International Plant and Animal Genome Conference XXII that will be held January 11–15, 2014 in San Diego, CA.

Map QTL for Seed Isoflavone Contents in 'MD 96-7522' by 'Spencer' RIL population.

In Progress Manuscripts:

Akond M, L Schoener, SK Kantartzzi, K Meksem, Q Song, D Wang, Z Wen, DA Lightfoot, and MA Kassem. A SNP-Based Genetic Linkage Map of Soybean Using the SoySNP6K Illumina Infinium BeadChip Genotyping Array. *Journal of Plant Genome Sciences* 2013, Submitted – August 6, 2013.

Akond M, N Bellaloui, M Bonie, SK Kantartzzi, K Meksem, and MA Kassem. Quantitative Trait Loci for Seed Isoflavones in the 'MD 96-7522' by 'Spencer' Recombinant Inbred Lines of Soybean [Glycine max (L.) Merr.]. *Journal of Plant Genome Sciences* 2013, In Preparation.

Abstracts:

Several abstracts will be presented at the International Plant and Animal Genome Conference XXII that will be held January 11–15, 2014 in San Diego, CA.

Year 3:

August 1, 2013 – May 31, 2014

(2013-2014) Map QTL for Seed Isoflavone Contents in 'Hamilton' by 'Spencer' RIL population. Achieved Akond A, S Liu, SK Kantartzzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. A SNP Genetic Linkage Map Based on the 'Hamilton' by 'Spencer' Recombinant Inbred Line (RIL) Population of Soybean [Glycine max (L.) Merr.] Identified QTL for Seed Isoflavone Contents. *PLoS ONE*, 2014. Submitted.

Map QTL for Seed Protein Contents in 'Hamilton' by 'Spencer' RIL population. Achieved and In Progress

Akond A, S Liu, SK Kantartzzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, Fatty and Amino Acids' Contents in 'Hamilton' by 'Spencer' population of Soybean. 2014. In Preparation.

Map QTL for Seed Oil Contents in 'Hamilton' by 'Spencer' RIL population. Achieved and In Progress

Akond A, S Liu, SK Kantartzzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, Fatty and Amino Acids' Contents in 'Hamilton' by 'Spencer' population of Soybean. 2014. In Preparation.

Map QTL for Root Traits in 'Hamilton' by 'Spencer' RIL population. Achieved and In Progress

Akond A, Z Ambrocio, SK Kantartzzi, K Meksem, and MA Kassem. QTL analysis of root traits and relative water contents as related to water availability in Hamilton by Spencer population of Soybean. 2014. In Preparation.

During the last period (Year 3), the following tasks were achieved:

1. Dr. Akond (Postdoctoral Fellow) and graduate student (Ms. Zenis Ambrocio) grew the 'Hamilton' by 'Spencer' RIL population both in the greenhouse and the field and they extracted DNA from the parents and RILs (96 samples). The DNA was checked for quality and was sent to Dr. Dechun Wang of Michigan State University for SNP genotyping.
2. Dr. Dechun Wang and Dr. Qijian Song performed the SNP genotyping in late 2013 and delivered the results to me (Dr. Kassem) by early January-February 2014. Dr. Akond (and later Dr. Song) constructed the genetic linkage map based on the 'Hamilton' by 'Spencer' RIL population and drafted the manuscript:

Akond A, S Liu, SK Kantartzzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. A SNP Genetic Linkage Map Based on the 'Hamilton' by 'Spencer' Recombinant Inbred Line (RIL) Population of Soybean [Glycine max (L.) Merr.] Identified QTL for Seed Isoflavone Contents. *PLoS ONE*, 2014. Submitted.

3. The RILs and parents have been harvested in the field around September-October 2013 and seeds have been sent to Dr. Nacer Bellaloui of USDA-ARS in Stoneville, MS. Dr. Bellaloui and his team performed the quantification of seeds isoflavones, oil, proteins, and sugars in the population and delivered the results to me late February-March 2014.

4. A preliminary QTL data analysis was performed after the genetic linkage map was constructed (Akond et al., 2014, unpublished). Dr. Akond and Ms. Ambrocio (Grad Student) did the QTL data analysis using WINQTL Cartographer and SAS Genomics software. A preliminary analysis revealed that we have discovered new QTL for seed isoflavones, protein, oil, sugar contents, and several other agronomic traits in this population. The following manuscripts are in preparation and will be submitted soon for publication:

Akond A, S Liu, SK Kantartzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. A SNP Genetic Linkage Map Based on the 'Hamilton' by 'Spencer' Recombinant Inbred Line (RIL) Population of Soybean [Glycine max (L.) Merr.] Identified QTL for Seed Isoflavone Contents. PLoS ONE, 2014. Submitted.

Akond A, S Liu, SK Kantartzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, Fatty and Amino Acids' Contents in 'Hamilton' by 'Spencer' population of Soybean. 2014. In Preparation.

Akond A, S Liu, SK Kantartzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, Fatty and Amino Acids' Contents in 'Hamilton' by 'Spencer' population of Soybean. 2014. In Preparation.

Akond A, Z Ambrocio, SK Kantartzi, K Meksem, and MA Kassem. QTL analysis of root traits and relative water contents as related to water availability in Hamilton by Spencer population of Soybean. 2014. In Preparation.

5. Ms. Zenis Ambrocio, a minority student, is writing her thesis (MS level) on genetic analysis of protein and oil contents in the 'Hamilton' x 'Spencer' RIL population (HxS, n=100). She was supported by this grant.

6. Mr. Bobby Ragin, a minority student, was selected and hired as the second Graduate Student (MS level) according to the grant on January 2, 2013. He was supported for 1.5 years and finished his MS degree and graduate in spring 2014. He was admitted to a PhD program at NC Central University and will start fall 2014. He worked on genetic mapping of QTL for seed isoflavones, protein, and oil contents and other agronomic traits and published the following manuscripts:

Ragin B, M Akond, SK Kantartzi, K Meksem, H Herrera, C Akbay, DA Lightfoot, and MA Kassem. Effect of Row Spacing on Seed Isoflavone Contents in Soybean [Glycine max (L.) Merr.]. American Journal of Plant Sciences, 2014. Submitted.

Akond M, R Bazelle, B Ragin, H Herrera, U Kaodi, C Akbay, SK Kantartzi, V Njiti, A Barakat, K Meksem, DA Lightfoot, and MA Kassem. Additional Quantitative Trait Loci and Candidate Genes for Seed Isoflavone Content in Soybean. J. Agricultural Science 5 (11): 20-33, October 2013.

Akond M, B Ragin, R Bazzelle, W Clark, SK Kantartzi, K Meksem, and MA Kassem. Effect of Two Row Spaces on Several Agronomic Traits in Soybean [Glycine max (L.) Merr.]. Atlas Journal of Plant Biology 1 (2): 18–23, 2013.

Akond M, B Ragin, R Bazzelle, SK Kantartzi, K Meksem, and MA Kassem. Quantitative Trait Loci Associated with Moisture, Protein, and Oil Content in Soybean [Glycine max (L.) Merr.]. Journal of Agricultural Science 4 (11): 16-25, October 2012.

Ragin B, R Bazelle, W Clark, S Kantartzi, K Meksem, and MA Kassem. QTL for Yield and Yield Components Mapped in the PI 438489B By 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean [Glycine max (L.) Merr.]. Journal of Agricultural Science 4 (9): 98-105, September 2012.

7. Ms. Zenis Ambrocio, another minority graduate student, was selected to work in Kassem's Lab to work towards her MS in Biology degree. She is not supported by the grant as far as a scholarship; however, the grant supports buying research supplies, etc. for her project. Her project title is: "Phenotyping, quantitative trait loci mapping, and identifying of genomic regions controlling root architecture in soybean". She started January 2, 2013 and is expected to graduate spring 2014; however, due to family issues, she will continue and is expected to graduate in fall 2014. She is writing her MS thesis:

Ambrocio Zenis – Thesis title: "QTL Mapping of Seed Isoflavone, Protein, and Oil Contents in the 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean."

The third and last year (2013-2014) of the grant was also productive, as usual, for Dr. Kassem, his Postdoc, and his undergraduate and graduate students. They presented the following presentations (Posters and Oral Presentations): Kassem MA, Akond M, S Liu, M Boney, SK Kantartzi, K Meksem, N Bellaloui, and DA Lightfoot, and. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, and Five Major Fatty Acids' Contents in Soybean. NC Academy of Science 111th Annual Meeting, March 28–29, 2014, NC Museum of Natural Sciences, Raleigh, NC. Oral Presentation.

Anderson JA, A Masum, MA Kassem, K Meksem, and S Kantartzi. Quantitative Trait Loci Underlying Resistance to Sudden Death Syndrome (SDS) in MD96-5722 By 'Spencer' Recombinant Inbred Line Population of Soybean. CSA, CSSA, & SSSA International Annual Meeting, November 2–5, 2014, Long Beach, CA.

Akond M, L Schoener, J Anderson, SK Kantartzi, K Meksem, Q Song, D Wang, Z Wen, DA Lightfoot, and MA Kassem. A SNP-Based Genetic Linkage Map of Soybean Using the SoySNP6K Illumina Infinium BeadChip Genotyping Array. Plant and Animal Genome Conference XXII, January 11–15, 2014, San Diego, CA, USA.

Akond M, R Bazelle, B Ragin, H Herrera, U Kaodi, C Akbay, SK Kantartzi, V Njiti, A Barakat, K Meksem, DA Lightfoot, and MA Kassem. Additional Quantitative Trait Loci and Candidate Genes for Seed Isoflavone Content in Soybean. Plant and Animal Genome Conference XXII, January 11–15, 2014, San Diego, CA, USA.

The latest results on 'Hamilton' by 'Spencer' RIL population will be presented as posters and oral presentations at the International Plant and Animal Genome Conference XXIII, January 10–14, 2015, San Diego, CA, USA and at the AMAS II Conference, October 20–22, 2014, Marrakech, Morocco.

In summary (2011-2014), the PI, Co-PI, colleagues, and students published, submitted, and are preparing the following manuscripts:

Published Manuscripts:

Akond M, B Ragin, R Bazzelle, W Clark, SK Kantartzi, K Meksem, and MA Kassem. Effect of Two Row Spaces on Several Agronomic Traits in Soybean [Glycine max (L.) Merr.]. *Atlas Journal of Plant Biology* 1 (2): 18–23, 2013.

Akond M, B Ragin, R Bazzelle, SK Kantartzi, K Meksem, and MA Kassem. Quantitative Trait Loci Associated with Moisture, Protein, and Oil Content in Soybean [Glycine max (L.) Merr.]. *Journal of Agricultural Science* 4 (11): 16-25, October 2012.

Ragin B, R Bazelle, W Clark, S Kantartzi, K Meksem, and MA Kassem. QTL for Yield and Yield Components Mapped in the PI 438489B By 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean [Glycine max (L.) Merr.]. *Journal of Agricultural Science* 4 (9): 98-105, September 2012.

Salvador V, M Pagan, M Cooper, SK Kantartzi, K Meksem, and MA Kassem. Genetic Analysis of Relative Water Content (RWC) in Two Recombinant Inbred Line Populations of Soybean [Glycine max (L.) Merr.]. *Journal of Plant Genome Sciences* 1 (2): 46-53, 2012.

Kassem MA, L Ramos, L Leandro, G Mbofung, DL Hyten, SK Kantartzi, RL Grier, VN Njiti, S Cianzio, and K Meksem. The 'PI 438489B' by 'Hamilton' SNP-Based genetic linkage map of soybean [Glycine max (L.) Merr.] identified quantitative trait loci that underlie seedling SDS resistance. *Journal of Plant Genome Sciences* 1 (1) 18–30, 2012.

Williams B, SK Kantartzi, K Meksem, and MA Kassem. Genetic Analysis of Root and Shoot Traits in the Soybean [Glycine max (L.) Merr.] 'Essex' By 'Forrest' Recombinant Inbred Line Population. *Journal of Plant Genome Sciences* 1 (1): 1–9, 2012.

Ivey S, K Ouertani, E Washington, P Lage, SK Kantartzi, K Meksem, DA Lightfoot, and MA Kassem. Evaluation of Agronomic Traits in 'Essex' By 'Forrest' Recombinant Inbred Line Population of Soybean [Glycine max [L.] Merr.]. *Atlas Journal of Plant Biology* 1 (1): 13-17, 2011.

Ouertani K, E Washington, P Lage, S Woods, W Holland, L Moore, J Walker, DA Lightfoot, and MA Kassem. Comparison of Soybean [Glycine max (L.) Merr.] Yield, Yield Components, Root, and Shoot Traits in ESPS and CSPS. *Atlas Journal of Plant Biology* 1 (1): 1–5, 2011.

Submitted Manuscripts:

Akond A, S Liu, SK Kantartzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. A SNP Genetic Linkage Map Based on the 'Hamilton' by 'Spencer' Recombinant Inbred Line (RIL) Population of Soybean [Glycine max (L.) Merr.] Identified QTL for Seed Isoflavone Contents. *PLoS ONE*, 2014. Submitted.

Akond M, R Bazelle, B Ragin, H Herrera, U Kaodi, C Akbay, SK Kantartzi, VN Njiti, A Barakat, K Meksem, DA Lightfoot, and MA Kassem. Additional Quantitative Trait Loci and Candidate Genes for Seed Isoflavone Content in Soybean. *Journal of Plant Science* 2013. Submitted.

Bellaloui N, Y Hu, A Mengistu, MA Kassem, and CA Abel. Effects of foliar boron application on seed composition, cell wall boron, and seed δ 15N and δ 13C isotopes in soybean are influenced by water stress. *Frontiers in Plant Nutrition*, 2013. Submitted.

Bellaloui N, A Mengistu, and MA Kassem. Effects of Genetics and Environment on Fatty Acid Stability in Soybean Seed. *Food and Nutrition Sciences*, 2013, In Press.

Manuscripts in Preparation:

Akond A, S Liu, SK Kantartzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, Fatty and Amino Acids' Contents in 'Hamilton' by 'Spencer' population of Soybean. 2014. In Preparation.

Akond A, S Liu, SK Kantartzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, Fatty and Amino Acids' Contents in 'Hamilton' by 'Spencer' population of Soybean. 2014. In Preparation.

Akond A, Z Ambrocio, SK Kantartzi, K Meksem, and MA Kassem. QTL analysis of root traits and relative water contents as related to water availability in Hamilton by Spencer population of Soybean. 2014. In Preparation.

Posters Presented at Conferences:

Kassem MA, M Akond, B Ragin, R Bazzelle, SK Kantartzi, and K Meksem. Quantitative trait loci associated with moisture, protein, and oil content in soybean [Glycine max (L.) Merr.]. NC Academy of Science- Annual Meeting, April 5-6, 2013. Oral Presentation.

Akond M, B Ragin, R Bazzelle, and MA Kassem. Identification of Quantitative Trait Loci Associated with Isoflavone Contents in Soybean Seed. NC Academy of Science- Annual Meeting, April 5-6, 2013. Oral Presentation.

Akond M, B Ragin, R Bazzelle, SK Kantartzi, K Meksem and MA Kassem. Quantitative Trait Loci for Moisture, Protein, and Oil Content in Soybean [Glycine max (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12–16, 2013, San Diego, CA, USA.

Akond M, R Bobby, W Clark, SK Kantartzi, K Meksem, and MA Kassem. Row Spaces can affect Agronomic Traits in Soybean

[Glycine max (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12–16, 2013, San Diego, CA, USA.
Richard B, B Ragin, S K Kantartzi, Khalid Meksem, Masum Akond, and My Abdelmajid Kassem. Quantitative Trait Loci for Seed Isoflavones in the 'PI 438489B' by 'Hamilton' Recombinant Inbred Lines of Soybean [Glycine max (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12–16, 2013, San Diego, CA, USA.
Ragin B, M Akond, MA Kassem, Plant Densities Can Affect Isoflavone Accumulation in Soybean [Glycine max (L.) Merr.]. Student Research Conference 2013, Fayetteville State University, April 12-13, 2013, NC, USA.
Ragin B, M Akond, MA Kassem, The Evaluation of Drought Tolerant Behavior in Hamilton by Spencer Recombinant Inbred Lines of Soybeans [Glycine max (L.) Merr.]. The Association of Social and Behavioral Scientists- 78 Annual Conference- Cincinnati, Ohio, March 13-16, 2013, OH, USA.
Ragin B, M Akond, MA Kassem, Quantitative Trait Loci (QTL) for Seed Isoflavones Contents Mapped in the 'PI 438489B' by 'Hamilton' Recombinant Inbred Line Population of Soybean [Glycine max (L.) Merr.]. ABRCMS- Annual Biomedical Research Conference for Minority Students- Nov 7-10 2012 San Jose, CA, USA; NC 11th Annual OPT-ED Alliance Day- North Carolina State University, Oct 16, 2012, NC, USA.
Rogers J, M Akond, MA Kassem, Responses of Selected soybean [Glycine max (L.) Merrill] Breeding Lines under mild water deficit. FSU Student Research Conference, April 13, 2013, Fayetteville, NC, USA; State of North Carolina Undergraduate Research and Creativity Symposium, November 7, 2012, Duke University Fitzpatrick Atrium, Durham, NC, USA; North Carolina Alliance To Create Opportunity Through Education (OPT-ED), October 16, 2012, Raleigh, NC, USA.

Students Working in the Lab and their Projects:

Graduate:

Melanie Boney: Variation in Agronomic Characteristics and Seed Components of Maryland by Spencer Recombinant Inbred Lines Soybean (Glycine max L. Merr.)

Bobby Ragin: Variation and genetic analysis of Seed Isoflavones Components in Hamilton by Spencer Recombinant Inbred Lines of Soybean (Glycine max L. Merr.)

Zenis Ambrocio: Phenotyping and quantitative trait loci mapping identify core regions of the soybean genome controlling root architecture.

Undergraduates:

Lauren Schoener: Genetic studies of soybean controlling isoflavones and other seed components.

Charity Bldwin: Genetic analysis of drought tolerance in soybean.

Technology Transfer

**Fayetteville State University
College of Arts and Sciences
Department of Biological Sciences**

**Department of Defense (DoD)
Office of Naval Research (ONR)**

Final Report# 3

**Dr. Abdelmajid Kassem (PI)
And
Dr. Stella Kantartzzi (Co-PI)**

Project Timeframe Reported (June 1, 2011 – May 31, 2014)

Project: “Genetic Analysis of Seed Isoflavones, Protein, and Oil Contents in Soybean [*Glycine max* (L.) Merr.]”. Abdelmajid Kassem (PI) and Stella Kantartzzi (Co-PI)

Abstract

Soybean (*Glycine max* L.) is an important crop in the US and worldwide. It has numerous health benefits because of its high contents of protein, oil, isoflavones, and other bioactive compounds. However, it is susceptible to many biotic stresses such fungal, bacterial, and viral diseases and abiotic stresses such as drought and salinity. The objectives of this funded project were to map quantitative trait loci (QTL) for protein, oil, and isoflavones contents in three recombinant inbred line (RIL) populations of soybean. We have achieved 100% of the goals. We have constructed the genetic linkage maps based on the three recombinant inbred line (RIL) populations ‘PI 438489B’ by ‘Hamilton’ (PIxH, n=54) (Kassem et al., 2012), ‘Maryland 96-5722’ by ‘Spencer’ (MxS, n=100) (Akond et al., 2013), and ‘Hamilton’ by ‘Spencer’ (HxS, n=100) (Akond et al., 2014, under review). We also mapped quantitative trait loci (QTL) for protein, oil, isoflavone contents as well as other important agronomic traits in each of these RIL populations. The results have been disseminated through (1) high quality manuscripts published in well-respected international journals and (2) poster and oral presentations in local, regional, and international conferences. The results are summarized below.

The objectives of this grant were to genetically map quantitative trait loci (QTL) for seed isoflavones, protein, and oil contents in three recombinant inbred line (RIL) populations of soybean focusing on one RIL population per year (Table 1):

Table 1. A summary of the three-year period of the grant, its objectives, achievements, and evidences.

Year	Objectives	Achieved / In Progress	Evidence
	Map QTL for <u>Seed Protein</u> Contents in PI 438489B by 'Hamilton' RIL population.	Achieved	<p>Manuscripts:</p> <p>Kassem MA, L Ramos, L Leandro, G Mbofung, DL Hyten, SK. Kantartzi, RL Grier, VN Njiti, S Cianzio, and K Meksem. The 'PI 438489B' by 'Hamilton' SNP-Based Genetic Linkage Map of Soybean [<i>Glycine max</i> (L.) Merr.] Identified Quantitative Trait Loci that Underlie Seedling SDS Resistance. <i>Journal of Plant Genome Sciences</i> 1(1): 18-30, 2012.</p> <p>Akond M, B Ragin, R Bazzelle, SK. Kantartzi, K Meksem, and MA Kassem. Quantitative Trait Loci Associated with <u>Moisture, Protein, and Oil Contents</u> in Soybean [<i>Glycine max</i> (L.) Merr.]. <i>Journal of Agricultural Science</i> 4 (11): 16-25, October 2012.</p> <p>Abstracts:</p> <p>Kassem MA. "Quantitative Trait Loci (QTL) for <u>Moisture, Proteins, and Oil Contents</u> in 'PI 438489B' By 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean [<i>Glycine max</i> (L.) Merr.]". The 110th Meeting of the North Carolina Academy of Science, April 5-6, 2013, UNC Pembroke, Pembroke, NC.</p> <p>Masum Akond, Ragin Bobby, Willsheana Clark, Stella K. Kantartzi, Khalid Meksem, and MA Kassem. Row Spaces can affect Agronomic Traits in Soybean [<i>Glycine max</i> (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12–16, 2013, San Diego, CA, USA.</p> <p>Masum Akond, Bobby Ragin, Richard Bazzelle, Stella K. Kantartzi, Khalid Meksem, and MA Kassem. Quantitative Trait Loci for <u>Moisture, Protein, and Oil Contents</u> in Soybean [<i>Glycine max</i> (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12–16, 2013, San Diego, CA, USA.</p>
	Map QTL for <u>Seed Oil</u> Contents in PI 438489B by 'Hamilton' RIL population.	Achieved	<p>Manuscripts:</p> <p>Kassem MA, L Ramos, L Leandro, G Mbofung, DL Hyten, SK. Kantartzi, RL Grier, VN Njiti, S Cianzio, and K Meksem. The 'PI 438489B' by</p>

<p>Year 1: June 1, 2011 – July 31, 2012 (2011-2012)</p>			<p>‘Hamilton’ SNP-Based Genetic Linkage Map of Soybean [<i>Glycine max</i> (L.) Merr.] Identified Quantitative Trait Loci that Underlie Seedling SDS Resistance. Journal of Plant Genome Sciences 1(1): 18-30, 2012. Akond M, B Ragin, R Bazzelle, SK Kantartzi, K Meksem, and MA Kassem. Quantitative Trait Loci Associated with <u>Moisture, Protein, and Oil Contents</u> in Soybean [<i>Glycine max</i> (L.) Merr.]. Journal of Agricultural Science 4 (11): 16-25, October 2012.</p> <p>Abstracts:</p> <p>Kassem MA. “Quantitative Trait Loci (QTL) for <u>Moisture, Proteins, and Oil Contents</u> in ‘PI 438489B’ By ‘Hamilton’ Recombinant Inbred Line (RIL) Population of Soybean [<i>Glycine max</i> (L.) Merr.]”. The 110th Meeting of the North Carolina Academy of Science, April 5-6, 2013, UNC Pembroke, Pembroke, NC.</p> <p>Masum Akond, Ragin Bobby, Willsheana Clark, Stella K. Kantartzi, Khalid Meksem, and MA Kassem. Row Spaces can affect Agronomic Traits in Soybean [<i>Glycine max</i> (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12–16, 2013, San Diego, CA, USA.</p>
	<p>Map QTL for <u>Seed Isoflavone</u> Contents in PI 438489B by ‘Hamilton’ RIL population.</p>	Achieved	<p>Manuscripts:</p> <p>Akond M, B Richard, B Ragin, H Herrera, U Kaodi, C Akbay, SK Kantartzi, VN Njiti, A Barakat, K Meksem, DA Lightfoot, and MA Kassem. Additional Quantitative Trait Loci and Candidate Genes for Seed Isoflavone Content in Soybean. Journal of Plant Science 2013, <u>Submitted</u>.</p> <p>Abstracts:</p> <p>Kassem MA. Quantitative Trait Loci (QTL) for Seed Isoflavones Content in ‘PI 438489B’ By ‘Hamilton’ Recombinant Inbred Line (RIL) Population of Soybean [<i>Glycine max</i> (L.) Merr.]. The First International American Moroccan Agricultural Sciences Conference – AMAS Conference I, March 18–19, 2013, Rabat, Morocco. <u>Oral Presentation</u>.</p> <p>Bazzelle Richard, Bobby Ragin, Stella Kantartzi, Khalid Meksem, Masum Akond, and MA Kassem. Quantitative Trait Loci for Seed Isoflavones in the ‘PI 438489B’ by ‘Hamilton’ Recombinant Inbred Lines of Soybean [<i>Glycine max</i> (L.) Merr.]. Plant and Animal Genome</p>

			Conference XXI, January 12–16, 2013, San Diego, CA, USA.
<p>Year 2: August 1, 2012 – July 31, 2013 (2012-2013)</p>	Map QTL for <u>Seed Protein</u> Contents in 'MD 96-7522' by 'Spencer' RIL population.	In Progress	<p>Manuscripts:</p> <p>Akond M, L Schoener, SK Kantartzi, K Meksem, Q Song, D Wang, Z Wen, DA Lightfoot, and MA Kassem. <i>A SNP-Based Genetic Linkage Map of Soybean Using the SoySNP6K Illumina Infinium BeadChip Genotyping Array</i>. <i>Journal of Plant Genome Sciences</i> 2013, <u>Submitted – August 6, 2013</u>.</p> <p>Akond M, N Bellaloui, M Bonie, SK Kantartzi, K Meksem, and MA Kassem. Quantitative Trait Loci for <u>Seed Protein and Oil Contents</u> in the 'MD 96-7522' by 'Spencer' Recombinant Inbred Lines of Soybean [<i>Glycine max</i> (L.) Merr.]. <i>Journal of Plant Genome Sciences</i> 2013, <u>In Preparation</u>.</p> <p>Abstracts:</p> <p>Several abstracts will be presented at the International Plant and Animal Genome Conference XXII that will be held January 11–15, 2014 in San Diego, CA.</p>
	Map QTL for <u>Seed Oil</u> Contents in 'MD 96-7522' by 'Spencer' RIL population.	In Progress	<p>Manuscripts:</p> <p>Akond M, L Schoener, SK Kantartzi, K Meksem, Q Song, D Wang, Z Wen, DA Lightfoot, and MA Kassem. <i>A SNP-Based Genetic Linkage Map of Soybean Using the SoySNP6K Illumina Infinium BeadChip Genotyping Array</i>. <i>Journal of Plant Genome Sciences</i> 2013, <u>Submitted – August 6, 2013</u>.</p> <p>Akond M, N Bellaloui, M Bonie, SK Kantartzi, K Meksem, and MA Kassem. Quantitative Trait Loci for <u>Seed Protein and Oil Contents</u> in the 'MD 96-7522' by 'Spencer' Recombinant Inbred Lines of Soybean [<i>Glycine max</i> (L.) Merr.]. <i>Journal of Plant Genome Sciences</i> 2013, <u>In Preparation</u>.</p> <p>Abstracts:</p> <p>Several abstracts will be presented at the International Plant and Animal Genome Conference XXII that will be held January 11–15, 2014 in San Diego, CA.</p>

<p>Year 3: August 1, 2013 – May 31, 2014 (2013-2014)</p>	<p>Map QTL for <u>Seed Isoflavone</u> Contents in 'MD 96-7522' by 'Spencer' RIL population.</p>	<p>In Progress</p>	<p>Manuscripts:</p> <p>Akond M, L Schoener, SK Kantartzi, K Meksem, Q Song, D Wang, Z Wen, DA Lightfoot, and MA Kassem. <i>A SNP-Based Genetic Linkage Map of Soybean Using the SoySNP6K Illumina Infinium BeadChip Genotyping Array</i>. Journal of Plant Genome Sciences 2013, <u>Submitted – August 6, 2013</u>.</p> <p>Akond M, N Bellaloui, M Bonie, SK Kantartzi, K Meksem, and MA Kassem. Quantitative Trait Loci for Seed Isoflavones in the 'MD 96-7522' by 'Spencer' Recombinant Inbred Lines of Soybean [<i>Glycine max</i> (L.) Merr.]. Journal of Plant Genome Sciences 2013, <u>In Preparation</u>.</p> <p>Abstracts:</p> <p>Several abstracts will be presented at the International Plant and Animal Genome Conference XXII that will be held January 11–15, 2014 in San Diego, CA.</p>
	<p>Map QTL for <u>Seed Isoflavone</u> Contents in 'Hamilton' by 'Spencer' RIL population.</p>	<p>Achieved</p>	<p>Akond A, S Liu, SK Kantartzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. A SNP Genetic Linkage Map Based on the 'Hamilton' by 'Spencer' Recombinant Inbred Line (RIL) Population of Soybean [<i>Glycine max</i> (L.) Merr.]. Identified QTL for Seed Isoflavone Contents. <u>PLoS ONE</u>, 2014. Submitted.</p>
	<p>Map QTL for <u>Seed Protein</u> Contents in 'Hamilton' by 'Spencer' RIL population.</p>	<p>Achieved and In Progress</p>	<p>Akond A, S Liu, SK Kantartzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, Fatty and Amino Acids' Contents in 'Hamilton' by 'Spencer' population of Soybean. <u>2014. In Preparation</u>.</p>
	<p>Map QTL for <u>Seed Oil</u> Contents in 'Hamilton' by 'Spencer' RIL population.</p>	<p>Achieved and In Progress</p>	<p>Akond A, S Liu, SK Kantartzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, Fatty and Amino Acids' Contents in 'Hamilton' by 'Spencer' population of Soybean. <u>2014. In Preparation</u>.</p>
	<p>Map QTL for <u>Root Traits</u> in 'Hamilton' by 'Spencer' RIL population.</p>	<p>Achieved and In Progress</p>	<p>Akond A, Z Ambrocio, SK Kantartzi, K Meksem, and MA Kassem. QTL analysis of root traits and relative water contents as related to water availability in Hamilton by Spencer population of Soybean. <u>2014. In Preparation</u>.</p>

During the last period (Year 3), the following tasks were achieved:

1. Dr. Akond (Postdoctoral Fellow) and graduate student (Ms. Zenis Ambrocio) grew the 'Hamilton' by 'Spencer' RIL population both in the greenhouse and the field and they extracted DNA from the parents and RILs (96 samples). The DNA was checked for quality and was sent to Dr. Dechun Wang of Michigan State University for SNP genotyping.
2. Dr. Dechun Wang and Dr. Qijian Song performed the SNP genotyping in late 2013 and delivered the results to me (Dr. Kassem) by early January-February 2014. Dr. Akond (and later Dr. Song) constructed the genetic linkage map based on the 'Hamilton' by 'Spencer' RIL population and drafted the manuscript:

Akond A, S Liu, SK Kantartzzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. A SNP Genetic Linkage Map Based on the 'Hamilton' by 'Spencer' Recombinant Inbred Line (RIL) Population of Soybean [*Glycine max* (L.) Merr.] Identified QTL for Seed Isoflavone Contents. PLoS ONE, 2014. Submitted.

3. The RILs and parents have been harvested in the field around September-October 2013 and seeds have been sent to Dr. Nacer Bellaloui of USDA-ARS in Stoneville, MS. Dr. Bellaloui and his team performed the quantification of seeds isoflavones, oil, proteins, and sugars in the population and delivered the results to me late February-March 2014.
4. A preliminary QTL data analysis was performed after the genetic linkage map was constructed (Akond et al., 2014, unpublished). Dr. Akond and Ms. Ambrocio (Grad Student) did the QTL data analysis using WINQTL Cartographer and SAS Genomics software. A preliminary analysis revealed that we have discovered new QTL for seed isoflavones, protein, oil, sugar contents, and several other agronomic traits in this population. The following manuscripts are in preparation and will be submitted soon for publication:

Akond A, S Liu, SK Kantartzzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. A SNP Genetic Linkage Map Based on the 'Hamilton' by 'Spencer' Recombinant Inbred Line (RIL) Population of Soybean [*Glycine max* (L.) Merr.] Identified QTL for Seed Isoflavone Contents. PLoS ONE, 2014. Submitted.

Akond A, S Liu, SK Kantartzzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, Fatty and Amino Acids' Contents in 'Hamilton' by 'Spencer' population of Soybean. 2014. In Preparation.

Akond A, S Liu, SK Kantartzzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and MA Kassem. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, Fatty and Amino Acids' Contents in 'Hamilton' by 'Spencer' population of Soybean. 2014. In Preparation.

Akond A, Z Ambrocio, SK Kantartzzi, K Meksem, and MA Kassem. QTL analysis of root traits and relative water contents as related to water availability in Hamilton by Spencer population of Soybean. 2014. In Preparation.

5. Ms. Zenis Ambrocio, a minority student, is writing her thesis (MS level) on genetic analysis of protein and oil contents in the 'Hamilton' x 'Spencer' RIL population (HxS, n=100). She was supported by this grant.
6. Mr. Bobby Ragin, a minority student, was selected and hired as the second Graduate Student (MS level) according to the grant on January 2, 2013. He was supported for 1.5 years and finished his MS degree and graduate in spring 2014. He was admitted to a PhD program at NC Central University and will start fall 2014. He worked on genetic mapping of QTL for seed isoflavones, protein, and oil contents and other agronomic traits and published the following manuscripts:

Ragin B, M Akond, SK Kantartzi, K Meksem, H Herrera, C Akbay, DA Lightfoot, and MA Kassem. Effect of Row Spacing on Seed Isoflavone Contents in Soybean [*Glycine max* (L.) Merr.]. American Journal of Plant Sciences, 2014. Submitted.

Akond M, R Bazelle, **B Ragin**, H Herrera, U Kaodi, C Akbay, SK Kantartzi, V Njiti, A Barakat, K Meksem, DA Lightfoot, and MA Kassem. Additional Quantitative Trait Loci and Candidate Genes for Seed Isoflavone Content in Soybean. *J. Agricultural Science* 5 (11): 20-33, October 2013.

Akond M, **B Ragin**, R Bazzelle, W Clark, SK Kantartzi, K Meksem, and MA Kassem. Effect of Two Row Spaces on Several Agronomic Traits in Soybean [*Glycine max* (L.) Merr.]. *Atlas Journal of Plant Biology* 1 (2): 18-23, 2013.

Akond M, **B Ragin**, R Bazzelle, SK Kantartzi, K Meksem, and MA Kassem. Quantitative Trait Loci Associated with Moisture, Protein, and Oil Content in Soybean [*Glycine max* (L.) Merr.]. *Journal of Agricultural Science* 4 (11): 16-25, October 2012.

Ragin B, R Bazelle, W Clark, S Kantartzi, K Meksem, and MA Kassem. QTL for Yield and Yield Components Mapped in the PI 438489B By 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean [*Glycine max* (L.) Merr.]. *Journal of Agricultural Science* 4 (9): 98-105, September 2012.

7. Ms. Zenis Ambrocio, another minority graduate student, was selected to work in Kassem's Lab to work towards her MS in Biology degree. She is not supported by the grant as far as a scholarship; however, the grant supports buying research supplies, etc. for her project. Her project title is: "Phenotyping, quantitative trait loci mapping, and identifying of genomic regions controlling root architecture in soybean". She started January 2, 2013 and is expected to graduate spring 2014; however, due to family issues, she will continue and is expected to graduate in fall 2014. She is writing her MS thesis:

Ambrocio Zenis – Thesis title: "QTL Mapping of Seed Isoflavone, Protein, and Oil Contents in the 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean."

The third and last year (2013-2014) of the grant was also productive, as usual, for Dr. Kassem, his Postdoc, and his undergraduate and graduate students. They presented the following presentations (Posters and Oral Presentations):

Kassem MA, Akond M, S Liu, M Boney, SK Kantartzi, K Meksem, N Bellaloui, and DA Lightfoot, and. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, and Five Major Fatty Acids' Contents in Soybean. NC Academy of Science 111th Annual Meeting, March 28–29, 2014, NC Museum of Natural Sciences, Raleigh, NC. Oral Presentation.

Anderson JA, A Masum, **MA Kassem**, K Meksem, and S Kantartzi. Quantitative Trait Loci Underlying Resistance to Sudden Death Syndrome (SDS) in MD96-5722 By 'Spencer' Recombinant Inbred Line Population of Soybean. CSA, CSSA, & SSSA International Annual Meeting, November 2–5, 2014, Long Beach, CA.

Akond M, L Schoener, J Anderson, SK Kantartzi, K Meksem, Q Song, D Wang, Z Wen, DA Lightfoot, and **MA Kassem**. A SNP-Based Genetic Linkage Map of Soybean Using the SoySNP6K Illumina Infinium BeadChip Genotyping Array. Plant and Animal Genome Conference XXII, January 11–15, 2014, San Diego, CA, USA.

Akond M, R Bazelle, B Ragin, H Herrera, U Kaodi, C Akbay, SK Kantartzi, V Njiti, A Barakat, K Meksem, DA Lightfoot, and **MA Kassem**. Additional Quantitative Trait Loci and Candidate Genes for Seed Isoflavone Content in Soybean. Plant and Animal Genome Conference XXII, January 11–15, 2014, San Diego, CA, USA.

The latest results on 'Hamilton' by 'Spencer' RIL population will be presented as posters and oral presentations at the International Plant and Animal Genome Conference XXIII, January 10–14, 2015, San Diego, CA, USA and at the AMAS II Conference, October 20–22, 2014, Marrakech, Morocco.

In summary (2011–2014), the PI, Co-PI, colleagues, and students published, submitted, and are preparing the following manuscripts:

Published Manuscripts:

Akond M, B Ragin, R Bazzelle, W Clark, SK Kantartzi, K Meksem, and **MA Kassem**. Effect of Two Row Spaces on Several Agronomic Traits in Soybean [*Glycine max* (L.) Merr.]. *Atlas Journal of Plant Biology* 1 (2): 18–23, 2013.

Akond M, B Ragin, R Bazzelle, SK Kantartzi, K Meksem, and **MA Kassem**. Quantitative Trait Loci Associated with Moisture, Protein, and Oil Content in Soybean [*Glycine max* (L.) Merr.]. *Journal of Agricultural Science* 4 (11): 16–25, October 2012.

Ragin B, R Bazelle, W Clark, S Kantartzi, K Meksem, and **MA Kassem**. QTL for Yield and Yield Components Mapped in the PI 438489B By 'Hamilton' Recombinant Inbred Line (RIL) Population of Soybean [*Glycine max* (L.) Merr.]. *Journal of Agricultural Science* 4 (9): 98–105, September 2012.

Salvador V, M Pagan, M Cooper, SK Kantartzi, K Meksem, and **MA Kassem**. Genetic Analysis of Relative Water Content (RWC) in Two Recombinant Inbred Line Populations of Soybean [*Glycine max* (L.) Merr.]. *Journal of Plant Genome Sciences* 1 (2): 46–53, 2012.

Kassem MA, L Ramos, L Leandro, G Mbofung, DL Hyten, SK Kantartzi, RL Grier, VN Njiti, S Cianzio, and K Meksem. The ‘PI 438489B’ by ‘Hamilton’ SNP-Based genetic linkage map of soybean [*Glycine max* (L.) Merr.] identified quantitative trait loci that underlie seedling SDS resistance. *Journal of Plant Genome Sciences* 1 (1) 18–30, 2012.

Williams B, SK Kantartzi, K Meksem, and **MA Kassem**. Genetic Analysis of Root and Shoot Traits in the Soybean [*Glycine max* (L.) Merr.] ‘Essex’ By ‘Forrest’ Recombinant Inbred Line Population. *Journal of Plant Genome Sciences* 1 (1): 1–9, 2012.

Ivey S, K Ouertani, E Washington, P Lage, SK Kantartzi, K Meksem, DA Lightfoot, and **MA Kassem**. Evaluation of Agronomic Traits in ‘Essex’ By ‘Forrest’ Recombinant Inbred Line Population of Soybean [*Glycine max* [L.] Merr.]. *Atlas Journal of Plant Biology* 1 (1): 13-17, 2011.

Ouertani K, E Washington, P Lage, S Woods, W Holland, L Moore, J Walker, DA Lightfoot, and **MA Kassem**. Comparison of Soybean [*Glycine max* (L.) Merr.] Yield, Yield Components, Root, and Shoot Traits in ESPS and CSPS. *Atlas Journal of Plant Biology* 1 (1): 1–5, 2011.

Submitted Manuscripts:

Akond A, S Liu, SK Kantartzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and **MA Kassem**. A SNP Genetic Linkage Map Based on the ‘Hamilton’ by ‘Spencer’ Recombinant Inbred Line (RIL) Population of Soybean [*Glycine max* (L.) Merr.] Identified QTL for Seed Isoflavone Contents. *PLoS ONE*, 2014. Submitted.

Akond M, R Bazelle, B Ragin, H Herrera, U Kaodi, C Akbay, SK Kantartzi, VN Njiti, A Barakat, K Meksem, DA Lightfoot, and **MA Kassem**. Additional Quantitative Trait Loci and Candidate Genes for Seed Isoflavone Content in Soybean. *Journal of Plant Science* 2013. Submitted.

Bellaloui N, Y Hu, A Mengistu, **MA Kassem**, and CA Abel. Effects of foliar boron application on seed composition, cell wall boron, and seed $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ isotopes in soybean are influenced by water stress. *Frontiers in Plant Nutrition*, 2013. Submitted.

Bellaloui N, A Mengistu, and **MA Kassem**. Effects of Genetics and Environment on Fatty Acid Stability in Soybean Seed. *Food and Nutrition Sciences*, 2013, In Press.

Manuscripts in Preparation:

Akond A, S Liu, SK Kantartzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and **MA Kassem**. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, Fatty and Amino Acids’ Contents in ‘Hamilton’ by ‘Spencer’ population of Soybean. 2014. In Preparation.

Akond A, S Liu, SK Kantartzi, K Meksem, N Bellaloui, DA Lightfoot, J Yuan, D Wang, and **MA Kassem**. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, Fatty and Amino Acids’ Contents in ‘Hamilton’ by ‘Spencer’ population of Soybean. 2014. In Preparation.

Akond A, Z Ambrocio, SK Kantartzi, K Meksem, and **MA Kassem**. QTL analysis of root traits and relative water contents as related to water availability in Hamilton by Spencer population of Soybean. 2014. In Preparation.

Posters Presented at Conferences:

Kassem MA, M Akond, B Ragin, R Bazzelle, SK Kantartzi, and K Meksem. Quantitative trait loci associated with moisture, protein, and oil content in soybean [*Glycine max* (L.) Merr.]. NC Academy of Science- Annual Meeting, April 5-6, 2013. Oral Presentation.

Akond M, B Ragin, R Bazzelle, and MA Kassem. Identification of Quantitative Trait Loci Associated with Isoflavone Contents in Soybean Seed. NC Academy of Science- Annual Meeting, April 5-6, 2013. Oral Presentation.

Akond M, B Ragin, R Bazzelle, SK Kantartzi, K Meksem and MA Kassem. Quantitative Trait Loci for Moisture, Protein, and Oil Content in Soybean [*Glycine max* (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12–16, 2013, San Diego, CA, USA.

Akond M, R Bobby, W Clark, SK Kantartzi, K Meksem, and MA Kassem. Row Spaces can affect Agronomic Traits in Soybean [*Glycine max* (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12–16, 2013, San Diego, CA, USA.

Richard B, B Ragin, S K Kantartzi, Khalid Meksem, Masum Akond, and My Abdelmajid Kassem. Quantitative Trait Loci for Seed Isoflavones in the ‘PI 438489B’ by ‘Hamilton’ Recombinant Inbred Lines of Soybean [*Glycine max* (L.) Merr.]. Plant and Animal Genome Conference XXI, January 12–16, 2013, San Diego, CA, USA.

Ragin B, M Akond, MA Kassem, Plant Densities Can Affect Isoflavone Accumulation in Soybean [*Glycine max* (L.) Merr.]. Student Research Conference 2013, Fayetteville State University, April 12-13, 2013, NC, USA.

Ragin B, M Akond, MA Kassem, The Evaluation of Drought Tolerant Behavior in Hamilton by Spencer Recombinant Inbred Lines of Soybeans [*Glycine max* (L.) Merr.]. The Association of Social and Behavioral Scientists- 78 Annual Conference- Cincinnati, Ohio, March 13-16, 2013, OH, USA.

Ragin B, M Akond, MA Kassem, Quantitative Trait Loci (QTL) for Seed Isoflavones Contents Mapped in the ‘PI 438489B’ by ‘Hamilton’ Recombinant Inbred Line Population of Soybean [*Glycine max* (L.) Merr.]. ABRCMS- Annual Biomedical Research Conference for Minority Students- Nov 7-10 2012 San Jose, CA, USA; NC 11th Annual OPT-ED Alliance Day- North Carolina State University, Oct 16, 2012, NC, USA.

Rogers J, M Akond, MA Kassem, Responses of Selected soybean [*Glycine max* (L.) Merrill] Breeding Lines under mild water deficit. FSU Student Research Conference, April 13, 2013, Fayetteville, NC, USA; State of North Carolina Undergraduate Research and Creativity Symposium, November 7, 2012, Duke University Fitzpatrick Atrium, Durham, NC, USA; North Carolina Alliance To Create Opportunity Through Education (OPT-ED), October 16, 2012, Raleigh, NC, USA.

Students Working in the Lab and their Projects:**Graduate:**

Melanie Boney: Variation in Agronomic Characteristics and Seed Components of Maryland by Spencer Recombinant Inbred Lines Soybean (*Glycine max* L. Merr.)

Bobby Regin: Variation and genetic analysis of Seed Isoflavones Components in Hamilton by Spencer Recombinant Inbred Lines of Soybean (*Glycine max* L. Merr.)

Zenis Ambrocio: Phenotyping and quantitative trait loci mapping identify core regions of the soybean genome controlling root architecture.

Undergraduates:

Lauren Schoener: Genetic studies of soybean controlling isoflavones and other seed components.

Charity Bldwin: Genetic analysis of drought tolerance in soybean.